Acta Bot. Croat. 65 (2), 117–125, 2006

CODEN: ABCRA 25
ISSN 0365–0588

Influence of weeds on the growth of *Pinus pinea* L. during reforestation in Palencia (Spain)

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A study was carried out on the influence of spontaneous vegetation on the growth of reforested *Pinus pinea* L. (stone pine) seedlings in abandoned cropland. Ninety seedlings were randomly selected. In half of them weeds were removed and the remaining 45 were not treated. The research lasted from November 1998 to October 1999. The studied area was located 7 km from Palencia city (Northern Spain). The pine trees were planted in ridges. Weed mean cover around the untreated seedlings was 12.38%. Greatest height growth in pine seedling occurred in April. Significant differences were observed between different treatments. Weeds reduce the height of the pine trees, although the effect was not very remarkable. There was a significant negative relation between tree diameter and weed. The average growth of the pine trees regarding height was 24.44% and 50.14% regarding diameter. In general, there was more growth in the diameter than in height, because the reforested species consume more energy-producing underground or supporting biomass in dry areas.

Key words: Reforestation, *Pinus pinea*, seedlings, growth, weed, competition, Spain

Introduction

Farm land reforestation has been fostered within the common agricultural policy of the European Union since 1993. Spain took advantage of this project, and of more than 350,000 ha, 8000 ha have been reforested in Castilla y León over the last ten years. This policy is very important, because Spain is a country where desertification is clearly in progress. Water washes away more than 10^9 t soil every year (MESANZA 1985)

Some authors such as TRIPLETT et al. (1968) confirm that soils covered with vegetation have higher infiltration capacity due to probably greater porosity and better structure. Provisin of plant cover is the best way to fight erosion, especially herbaceous cover with low aspect (MORGAN 1991). The main aim of reforestation of this steppe area is the mitigation of erosion and desertification, and protection and improvement of soil, water, fauna and flora.

Pinus pinea L. is one of the most widely used species in the afforestation of semiarid areas of the Duero Plateau (Northern Spain). This heliophyte has a great colonising capacity

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and is native to the Mediterranean basin. The largest stands are in the Iberian Peninsula, and its plantation has been highly promoted by European policy of the afforestation of croplands (ÁLVAREZ et al. 2004).

Abandoned croplands have large seed banks, waiting for years to have the appropriate moment to germinate. The seed bank contributes significantly to the dynamics of plant communities (LEBRETON et al. 1991), and it is a reserve for population renewal and where a certain genetic variability can be found (CHRISTENSEN and MULLER 1975).

Weeds may compete with the seedlings of forest species. Weeds have a greater efficacy to uptake water from the soil after rain episodes because they explore the upper soil horizons (CHAVASSE 1980).

Spontaneous vegetation sometimes creates an unimportant microhabitat that does not affect reforested tree species, but that at some other times will present a marked competition with these plants (OCAÑA et al. 1996). Therefore, it is necessary to assess its advantages and disadvantages.

There are many studies on the competition between weeds and edible plants (WEAVER et al. 1987, HENRY and BAUMAN 1991), and on weed colonisation of abandoned fields (MARCO MOLINA 1995, PADILLA BLANCO 1998). Similarly, some studies have analysed the effects of herbicides on the growth of pine seedlings (CANELLAS et al. 1999, ORTEGA-QUERO et al. 2001). Also, works that have related weed colonisation with the growth of species reforested have been done generally with oak species (GORDON et al. 1989; KOLB and STEINER 1990; REY BENAYAS et al. 1994, 2003, 2005; REY BENAYAS 1998).

The aim of this study is to know the composition of pioneer adventitious species which grow in plots reforested with *Pinus pinea* in Northwest Spain and to analyse the effect of weed cover on the growth of *Pinus pinea* seedlings.

Materials and methods

The study area was Cerro de las Yeseras (Villalobón, Palencia, Spain, 42° 05’ N, 4° 30’ W), at 775 m above sea level. The average annual rainfall is 392.9 mm, distributed homogeneously throughout autumn, winter and spring. The average temperature is 11.4 °C, the area has a long winters and short summers with marked temperature contrast. A physicochemical analysis of the soil was done in the area which had been reforested, using the standard method of analysis (MAPA 1994), taking samples up to 20 cm deep, in November 1998 (Tab. 1). Its texture ranges from silt to clay loam with a high quantity of gypsum. Soil is alkaline in nature. According to the classification of KLIGEBIEL and MONTGOMERY (1966), these plots would be included in group C, considered inappropriate for agriculture, but suitable for permanent vegetation. A high concentration of nitrogen was observed, since it was recently nevertheless used for agriculture. Since the percentage of total carbonates was very high, phosphorus content was reduced. The water regime in the soil is xeric, and the thermic regime is mesic.

Study plot was 1 ha that had been reforested. The plot is an abandoned dry field which had been cultivated with cereal the previous year. Trees were planted in ridges, leaving a 2 m distance between plants and ridges. In this plot 90 seedlings of pine tree were marked at random. In 45 seedlings weeds were removed monthly (treated plants) and the other 45 seedlings were not treated. The reforestation had been carried out with one-year-old *Pinus pinea* plants in April 1998. There was a monthly monitoring for one year, from November 1998 to October 1999.

Tab. 1. Physicochemical characteristics of the soil studied.

	Abandoned field
Orientation	S-W
Slope (%)	3
Altitud (m)	760
Sand (%)	27.35
Silt (%)	63.7
Clay (%)	8.95
Texture	silt-loam
pH	7.9
N (mg kg^{-1})	753.3
P (mg kg^{-1})	8
Ca+ (cmol kg^{-1})	72.3
Total Carbonates (%)	56.9
Mg+ (cmol kg^{-1})	0.2
K+ (mg kg^{-1})	235
Ca/Mg ratio	361.5
Ca/K ratio	120.5
Na+ (cmol kg^{-1})	0.1
Organic matter (%)	1

The sampling unit was a 2500 cm^2 circular surface around each untreated pine tree plant. The species which grew in these areas were identified, using keys and handbooks (TUTIN et al. 1964–1993, CASTROVIEJO et al. 1986–2003). Weed cover was visually estimated, using a rule as well, establishing the shadow projected (perpendicular to the soil surface) by this species within the limits of the area studied. The height of the pine trees was measured root collar to the upper needles. The diameter of the pine trees was also measured at the third ramification level during the first and last month of the study.

Statistical analyses were made with the SPSS software system (1998), using the procedures for simple linear regression and a t-student test.

Results and discussion

The average cover of adventitious plants around untreated pines was 12.38% and the maximum cover was 36.8%, which occurred in June (Fig. 1). From June to November, weed cover decreased. The cover of weed and growth of the pine trees were considerable. This could be due, to a certain extent, to the presence of mineral nutrients remains since this plot had been used for a barley crop recently.

It was observed that the plants of pine trees were mostly surrounded by weeds with smaller cover. The cover of weeds had a negative influence upon the growth of the pine trees. The elimination of weeds allowed *Quercus ilex* seedling to increase their growth (REY BENAYAS et al. 2005) and the same was observed with stone pine seedlings (CANELLAS et al. 1999). However, this influence was not very remarkable since there was not a marked shortage of water during the year of the study.

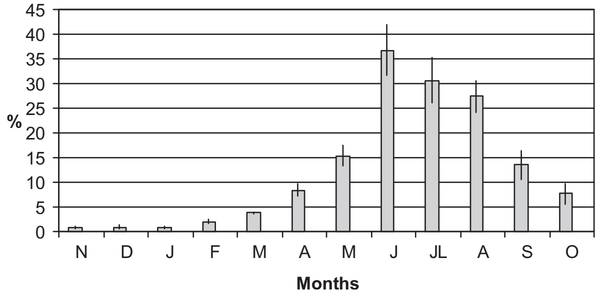

Fig. 1. Evolution of weed cover around *Pinus pinea* seedlings where weeds were not removed after plantation (untreated seedlings) in abandoned cropland. Data are means.

The presence of weeds played a very important role in reducing erosion. In areas where there was no cover of spontaneous plants, the stem of some pine trees was partly buried.

Figure 2 shows the average monthly height growth in both treatments of the pine trees regarding height in both treatments. The average growth over the whole period was 6.20 ± 2.16 cm (n=90). The height growth ranged between 1.7 and 8.6 cm. Three stages can be distinguished. The first one coincides with the autumn-winter period, when both pines and weed hardly grew at all. During a second stage, from March to July, pines trees grew fast, coinciding with good weather conditions. Height growth rate was higher in treated plants. Weed cover increased fast during the final period of this stage. During the third stage, the growth rate of the pine trees, diminished coinciding with the onset of summer.

The final growth reached by the pine trees at the end of the study was higher in the group of treated seedlings. These growth percentages regarding height were 23.57% in the untreated seedling and 25.32% in the group treated ones.

The growth of the pine trees concerning diameter was 49.18% for the group of pines without treatment and 51.11% in the group of treated pine trees, over the year of the study.

The correlation coefficients between height and diameter growth and weed cover were very low, r = – 0.078 and r = – 0.223 respectively. A significant negative relation was found between diameter growth and weed cover, P-value = 0.085, significant at the 90% confidence level.

Diameter increase is significantly different between weed treatments, t = 13.617; significant at the 95% confidence level.

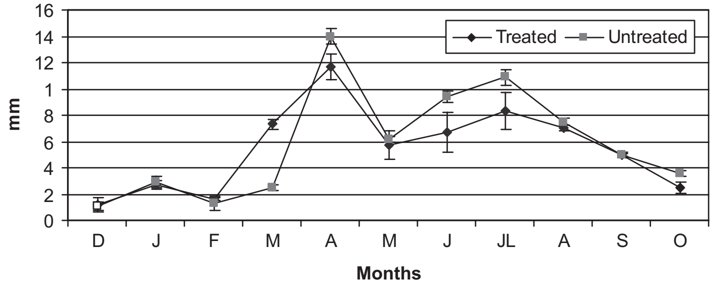

Fig. 2. Average monthly height growth (mm) of *Pinus pinea* seedlings in an abandoned field.

Annual height increments are very big for *Pinus pinea* seedlings, coinciding with those by some authors (PEÑUELAS 1996, STERNBER et al. 2001). As a result to their adaptation to a dry climate, the allocation of biomass to the below ground part is important, contributing to a very substantial growth of diameter of pine trees. Some authors observed a positive effect of the weed cover upon the reforested species, which was explained by the shade provided by weeds (KOLB and STEINER 1990, KOUKOURA and MENKE 1995, REY BENAYAS 1998, REY BENAYAS et al. 2002). It should be mentioned that some these data were obtained in experimental plots that were watered.

Survival of seedling was a very high during the first year. None of the marked seedlings died, which contrasts with the results of PEÑUELAS (1996), who observed that the survival of the pine seedlings was poor three years later. Herbicides, which sometimes cause significant mortality (ORTEGA QUERO et al. 2001), were not used in this reforestation. However, other authors (STERNBERS et al. 2001) found that seedling mortality significantly increased with decreasing intensities and frequencies of simazine applications. However, height and crown diameter of the surviving seedlings were not always significantly correlated to the amounts of herbicide sprayed.

Sixty nine species were recorded, belonging to 22 families (Tab. 2). The families represented by highest number of species were: Asteraceae (18 species), Brassicaceae (9 species), Poaceae (8 species), Leguminosae (7 species).

Tab. 2. List of recorded species in the studied plot, classified by biological type and chorological distribution.

Species	**Biological type**	**Chorology**
Achillea odrata L.	Hemicryptophytes	Mediterranean
Alyssum alyssoides L.	Terophytes	Mediterranean
Anacyclus clavatus (Desf.) Pers.	Terophytes	Mediterranean
Androsace maxima L.	Terophytes	Eurasian
Arabis verna (L.) R.Br.	Terophytes	Mediterranean
Astragalus glaux L.	Camephytes	Mediterranean
Avenula bromoides (Gouan) H.Scholz	Hemicryptophytes	Mediterranean
Avenula sulcata Gay ex Boys.	Hemicryptophytes	Mediterranean
Barbarea intermedia Boreau	Hemicryptophytes	Eurosiberian
Biscutella auriculata L.	Terophytes	Mediterranean
Bromus rubens L.	Terophytes	Cosmopolitan
Bupleurum baldense Turra	Terophytes	Mediterranean
Bupleurum rotundifolium L.	Terophytes	Eurasian
Carduus tenuiflorus Curtis	Terophytes	Eurasian
Centaurea aspera L.	Terophytes	Cosmopolitan
Chenopodium album L.	Terophytes	Cosmopolitan
Cirsium arvense (L.) Scoop.	Geophytes	Eurasian
Convolvulus arvensis L.	Terophytes	Cosmopolitan
Coronilla scopioides (L.) Koch.	Terophytes	Mediterranean
Crepis vesicaria L.	Hemicryptophytes	Mediterranean
Dactylis glomerata L.	Hemicryptophytes	Mediterranean
Daucus carota L.	Hemicryptophytes	Mediterranean
Echinops ritro L.	Hemicryptophytes	Central European

Tab. 2. – continued

Species	Biological type	Chorology
Erodium ciconium (L.) L. Hér	Hemicryptophytes	Mediterranean
Erodium cicutarium (L.) L. Hér	Terophytes	Mediterranean
Eruca vesicaria (L.) Cav.	Terophytes	Mediterranean
Erucastrum gallicum K. Presl.	Terophytes	Mediterranean
Euphorbia serrata L.	Geophytes	Mediterranean
Fedia cornucopiacea (L.) Gaertner	Terophytes	Mediterranean
Filago vulgaris Lam.	Terophytes	Mediterranean
Fumaria officinalis L.	Terophytes	Palaeotemperate
Fumaria parviflora Lam.	Terophytes	Mediterranean
Galium aparine L.	Terophytes	Eurasian
Helianthemun croceum (Desf.) Pers.	Camephytes	Mediterranean
Hieracium pilosella L.	Terophytes	Palaeotemperate
Hipocrepis multisiliquosa L.	Terophytes	Mediterranean
Koeleria vallesiana (Honk) Gaudin	Hemicryptophytes	Mediterranean
Lactuca serriola L.	Hemicryptophytes	Palaeotemperate
Linum trigynum L.	Terophytes	Mediterranean
Lolium perenne L.	Hemicryptophytes	Circumboreal
Matthiola fruticulosa (L.) Maire.	Camephytes	Mediterranean
Medicago sativa L.	Hemicryptophytes	Mediterranean
Muscari racemosum (L.) Lam.	Geophytes	Mediterranean
Omphalodes linifolia (L.) Moench	Terophytes	Mediterranean
Ononis tridentata L.	Camephytes	Mediterranean
Onopordum nervosum Boiss.	Hemicryptophytes	Mediterranean
Papaver dubium L.	Terophytes	Palaeotemperate
Papaver hibridum L.	Terophytes	Palaeotemperate
Papaver rhoeas L.	Terophytes	Mediterranean
Petrorhagia prolifera (L.) P.W. Ball & Heywood	Terophytes	Mediterranean
Picris echioides L.	Terophytes	Mediterranean
Poa annua L.	Terophytes	Cosmopolitan
Polygonum aviculare L.	Terophytes	Cosmopolitan
Rapistrum rugosum (L.) All.	Hemicryptophytes	Mediterranean
Sanguisorba minor Scop.	Hemicryptophytes	Mediterranean
Scolymus hispanicus L.	Hemicryptophytes	Mediterranean
Scorpiurus muricatus L.	Terophytes	Mediterranean
Scorzonera hispanica L.	Hemicryptophytes	Mediterranean
Senecio vulgaris L.	Hemicryptophytes	Cosmopolitan
Silene conoidea L.	Terophytes	Mediterranean
Sinapis arvensis L.	Terophytes	Palaeotemperate
Sonchus oleraceus L.	Hemicryptophytes	Cosmopolitan
Taeniantherum caput-medusae (L.) Nevski.	Terophytes	Mediterranean
Taraxacum officinale Weber	Hemicryptophytes	Eurasian
Trigonella polyceratia L.	Terophytes	Mediterranean
Vaccaria pyramidata Medicus	Terophytes	Mediterranean
Valerianella echinata (L.) DC.	Terophytes	Mediterranean
Veronica arvensis L.	Terophytes	Cosmopolitan
Xeranthemun inapertum (L.) Miller.	Terophytes	Mediterranean

The species with most cover were: *Centaurea aspera* L., *Papaver rhoeas* L., *Filago vulgaris* Lam, *Euphorbia serrata* L., *Onopordum nervosum* Boiss. and *Eruca vesicaria* (L) Cav.

There are a high proportion of therophytes. The species of *Matthiola fruticulosa* (L.) Maire, *Androsace maxima* L. and *Globularia vulgaris* L. have a fibrous root, which contributes to their early warming, making them flower very early.

Species with a taproot such as *Euphorbia serrata*, *Papaver rhoeas* and *Onopordum nervosum* flower later but they have a very high cover rate in a short time. These species have a lower competitive effect for water than fibrous grass root species, coinciding with the results of GORDON et al. (1989). *Cirsium arvense* (L.) Scoop. and creeping species such as *Polygonum aviculare* L. and *Convolvulus arvensis* L. grow at the end of the summer.

In June, most of the therophyte plants, except for the Asteraceae family, finished their life cycle although they remained in the plot as necromass.

Regarding the chorology, 62.3% of the species had a Mediterranean origin and 14.7% of them were cosmopolitan.

The presence of gypsum favoured the invasion of gypsicolous species. An abundance of calcium causes a block of micronutrients such as Fe, Bo, Zn, Cu, and macronutrients such as P, K and Mg (COBERTERA 1993). It is very difficult to improve these soils, since the output of P precipitates with calcium, preventing its assimilation. The presence of silt causes bad drainage and aeration of the soil, exacerbated by excess of gypsum. This restricts the growth of this species of pine due to the soil necessities (PRADA et al. 1997). However, the growth of the pine seedling was scarcely affected during the first year.

Acknowledgement

I would like to thank Mrs C. Fraile for her kind English translation of the manuscript.

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